Options, Opportunities and the Efficient Transition

A Report on the Technical Potential to Decarbonize Canada's Heavy Industry

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Executive Summary

Maintaining a maximum increase of 1.5-2°C in atmospheric temperature rise involves substantially decreasing CO2 emissions by 2050 and reducing them to net zero by 2075. However, Canada and the world will still need the material stuff of modern life. IGUA partnered with Dr. Christopher Bataille, who is one of the leading economists working on deep decarbonisation under the UN framework, to examine the technical potential for decarbonizing Canada's heavy industry. The purpose of the study was to inform the policy discourse underway today and facilitate setting a transition path towards eventual decarbonisation of heavy industry.

The Bataille study[1] catalogued the range of potential technology options for each sector, gauged their market readiness and identified policy opportunities for transitioning heavy industry to a low-carbon future. The industry sectors that the study focussed on were steel, mining, metals processing, forestry/pulp and paper, petrochemical, chemical, cement and glass.

Key findings:

- The world will need materials even in a low carbon future with half of today's material intensity;
- Technically feasible decarbonisation options exist for almost all heavy industry sectors in Canada using a combination of generic technologies and total process redesign;
- There are no commercially available technologies for retrofitting existing sites industrial facilities. Most technologies are in various stages of development;
- Canada can have a competitive advantage as a supplier of low-carbon (eventually carbon-free) commodities in a low-carbon future because we have the resource endowment, the trained workforce, the research capability and the industry;
- The enabling policy considerations required for transitioning heavy industry to a low-carbon future are:
    - Recognizing and accommodating the high upfront capital and long-term investment cycles of industry.
    - Developing a common vision and plan of action for heavy industry that accommodates de-carbonization pathways for each large operation based on regionally specific circumstances, and coordinates research, commercialization and labour force training.
    - Investing in R&D

The present report provides an overview of the Bataille technical potential study, and highlights the notable findings.

[1] Bataille, C., N. Melton, and S. Stiebert. August 2016. *The potential to decarbonize Canadian heavy industry: Technological and policy pathways for Canadian energy intense industry to thrive in a low carbon world*. Working paper. doi: 10.13140/RG.2.1.3375.5121

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Introduction

About IGUA

The Industrial Gas Users Association represents the interests of large mining, steel, pulp and paper, chemicals, refineries and manufacturing companies in Ontario and Québec in energy matters. IGUA member companies collectively employ 24,000 people in Canada and 750,000 people worldwide. They are significant sources of revenue for the federal and provincial governments and key engines of development in their local communities.

Context

In the past two years climate change has become a key focus of many provinces and the federal government. Alberta and Ontario have released new climate change plans; and Quebec and British Columbia have reaffirmed their existing plans . The federal government has re-engaged in international climate negotiations, and in November of 2015 signed the Paris Accord to limit greenhouse gas emissions needed to keep global temperature rise below 2 degrees Celsius. It has been in consultation with the provinces since then and is expected to release a Canada wide climate change plan this fall.

Most of the discourse in Canada on climate and energy however has lacked insight on opportunities and pathways for heavy industry (other than oil and gas producers) to reduce carbon emissions. This has been largely due to the fact that large facilities like mines, chemical plants, refineries, steel plants or paper mills are not readily comparable with one another, and also because reducing the carbon intensity of heavy industry requires more than the effective policy tools for residential and commercial sectors like energy efficiency and electrification. Little work has gone into understanding options for decoupling green house gas emissions from energy use in heavy industry.

Looking beyond Canada, different countries have adopted different pathways for carbon reduction to suit their particular economic fabric. Germany has focused on becoming a global leader in low emissions industry, and introduced policy instruments to grow its industrial base while reducing energy intensity of its economy. The United Kingdom has opted for de-industrialization as its path to lowering carbon emissions. Each government has opted for the option that gives it the most competitive advantage in the future. Canada needs to do the same; federal and provincial governments need to deploy policy instruments that reflect Canada's economic strengths and provide Canada with a competitive advantage in a low carbon future.

IGUA partnered with Dr. Christopher Bataille[2], who is one of the leading economists working on deep decarbonisation under the UN framework, to examine the technical potential for decarbonizing Canada's heavy industry. The purpose of the study was to inform policy discourse and facilitate setting a transition path towards eventual decarbonisation of heavy industry in Canada. The present report is a based on the detailed report provided by Dr. Bataille, which is attached for reference.

[2] Dr. Bataille is the co-leader of the Canadian Deep Decarbonization Pathways Project (DDPP), member of the global DDPP secretariat, Associate researcher with the Institute for Sustainable Development and International Relations (IDDRI) in Paris and Adjunct Professor at Simon Fraser University. He has a PhD in energy and climate change policy modeling from Simon Fraser University.

Scope
The study set out to explore the implications of decarbonisation for Canadian non-fossil fuel extraction heavy industry, and identify options of adaptation. The energy and emissions intensive industries sectors targeted in the study were:

- Cement
- Glass
- Iron and Steel
- Metal Processing
- Mining
- Refineries
- Chemicals
- Pulp and paper

Research Questions
- Can heavy industry continue to operate and grow in Ontario and Québec, and more generally Canada, in a world committed to decarbonizing?

- What options exist to decarbonize heavy industry?
  - What are the competitiveness implications of these options?
  - What positive approaches have other countries, regions, companies or institutions taken to meet these challenges?

Approach & Methods
The technical potential study was designed to provide an initial scoping survey of technologies that can reduce green house gas emissions in the heavy industry sectors identified above. It was not designed to be an exhaustive or in-depth review of the existing facilities and options open to them, which would have required another scale of resources. The study, therefore, confined itself to a quality literature review of the technical potential for decarbonizing heavy industry, using only peer-reviewed academic and trade literature and websites based on them.

The findings are catalogued in a database, to serve as a platform for the Deep Decarbonisation Pathways Project (DDPP) and other researchers to monitor technology options and to update the database over time. The database is not meant to be exhaustive but demonstrative of what is possible, and is meant to be the prototype for a living document that would be maintained and curated at an appropriate institution, and to provide policy makers a window into the advancements being made in industrial decarbonisation.

The technical potential study has assumed a future world where a priority is made to maintain a global temperature increase of maximum 1.5 – 2 degrees Celsius and maximum dematerialization has been pursued. It has not delved into the policy intricacies needed to bring about the concerted global action to get to such a future. It has, however, identified key the policy considerations required to make a successful transition to a low-carbon future.

Key Findings

The world will need materials in a low carbon future

Global projections for material consumption[3] in a low carbon world show that:

- More of today's bulk conventional materials (iron, steel, cement, glass, metals, chemicals and forest products) will be needed even when maximum dematerialization has been pursued and where material intensity has reduced by half.
- There will be additional demand for new low-carbon bulk commodities such as hydrogen, biofuels, polygeneration of electricity and chemicals, and synthetic hydrocarbon gas and liquids.

The low carbon world will, therefore, still need heavy industry to produce the bulk materials and finished products. The imperative is to de-couple greenhouse gas emissions from the production process, and aim for net-zero carbon industrial operations. Industry cannot expect to be a significant part of the world's carbon budget.

Canada stands among a very small group of developed countries that have a deep natural resource base and the technological knowhow to turn the natural resource endowment into bulk commodities and finished products. The question for Canada is whether it can turn its sizeable resource endowment, knowhow and industrial base to a competitive advantage and reap the social and economic benefits of being a global leader in the carbon free production of commodities.

Energy Efficiency and Electrification Are Necessary but Not Sufficient

According to the International Energy Agency[4], if the current best available technologies (BAT) were implemented in every industrial facility across the planet, global energy demand (and GHG emissions) from industry would reduce by around 20%. This is because many energy-intensive production processes are already near BAT for competitive reasons.

Canada's forestry and pulp/paper sector has reduced reliance on fossil fuel by 75%, using bio-mass from own process instead, in order to reduce operating cost. Canada's deep mines have innovated and extract material at a much lower energy and emissions intensity than competitors operating in jurisdiction with much lower labour costs. Canada's petrochemical industry and refineries use natural gas as feedstock when most of the rest of the world uses oil.

There is a growing consensus that additional measures beyond energy efficiency technologies are needed for heavy industry to approach net zero emissions. Breakthrough new processes technologies and wide spread adoption of combustion innovations such as using bio or synthetic hydrocarbons, oxy-hydrogen combustion and post process carbon capture use and sequestration (CCUS) become necessary. However most of these technologies use more energy than conventional best available technologies. Conversion of naturally occurring substances into hydrogen, oxygen or synthetic and bio-fuels requires energy; CCUS is even a more energy intensive process. Electrification of load where possible will also be necessary and will impose further efficiency loss from generation and transmission.

[3] Denis-Ryan, A., C. Bataille & F. Jotzo (2016): Managing carbon-intensive materials in a decarbonizing world without a global price on carbon, Climate Policy, DOI: 10.1080/14693062.2016.1176008

[4] IEA, 2014, Energy Technology Perspectives 2014: Harnessing Electricity's potential. Organization for Economic Co-operation and Development, Paris.

Therefore, ambitious low-carbon scenarios for energy intensive industry would need to have access to a larger pool of de-carbonised electricity supply.

Generic Options Exist to Decarbonise Heavy Industry, But Not Commercially Available Affordable Options

Besides efficiency and electrification, the Bataille study identified generic approaches for reducing GHG emission in industries that have historically relied on fossil fuels, that can be classified into three categories:

- Replacing the fossil input stream for feedstock and fuel with a carbon neutral alternative such as biomass, synthetic hydrocarbons and hydrogen;
- Capturing the carbon from post process emissions, using or storing it (CCUS);
- Developing wholly new industrial processes.

Each option has its challenges.

Replacing the Input Fossil Stream – The main candidates for replacing fossil input streams into industrial facilities are biomass, hydrogen and renewable and synthetic hydrocarbons. Biomass use is limited by the availability of land base and air quality issues resulting from its combustion. It may, however, prove effective in some applications. For example using switch grass to make cellulosic ethanol for transport fuel, bio diesel for heavy freight vehicles, or using bio-charcoal as the source of carbon and energy in virgin steel making. Hydrogen can potentially be used for combustion instead of fossil hydrocarbons. However, hydrogen is not a naturally occurring substance and needs to be manufactured either through reforming natural gas or through electrolysis of water, both of which require considerable energy. Where surplus renewable power is available, manufacturing hydrogen could be a viable option. Synthetic hydrocarbons also have the potential to displace fossil input streams, however the sheer volume of fossil streams that needs to be replaced relegates these to niche applications. For example, renewable natural gas from landfill, agricultural and forestry waste could displace natural gas and still permit the use of existing natural gas distribution network and end-use technologies. Availability and volume of waste stream will limit supply.

Carbon Capture Utilization and Storage (CCUS) – Post-process carbon capture from the effluent and its reuse or storage is technically viable for most industrial facilities but could be prohibitively expensive for facilities that lack the scale of natural gas processing plants or central electricity generation plants. A further limitation is the availability of suitable storage of the captured CO2 and the need for pipeline infrastructure and transportation to the storage site. CCUS could potentially become more attractive for industrial facilities when combined with oxy-fuel combustion that results in an almost pure CO2 effluent stream eliminating the need for flue gas separation. Oxygen, however, still needs to be manufactured.

Developing Wholly New Industrial Processes – Industry can also potentially develop wholly new processes that reduce the carbon content of the product. The Bataille study reviewed and catalogued potential technologies that can replace the current processes in for the production of cement, glass, iron and steel, for metal processing, mining, refineries, chemical production and pulp and paper. Dr. Bataille identified that "there is an R&D gap in heavy industry," and most of the potential technical options "will need extensive R&D and piloting," before widespread adoption of these technologies can occur.[5] Most of the new lower carbon industrial processes were deemed not suitable for retrofitting to existing

[5] Ibid p. 20.

industrial facilities in Canada and identified as requiring 1-2 investment cycles even to be able to use the existing sites. There was no reliable cost data available for any of the technologies.

For example, nine technologies were catalogued in the data base for reducing emissions from the cement sector. Of these nine technical options, two are in the conceptual phase; three undergoing pilot studies, one at a small-scale commercialization and two are commercial ready. Adding another layer of complexity is that three of the pilot options and the small-scale commercial options are only available for new build facilities and cannot be retrofitted to existing plants.

A review of the potential technologies for reducing emissions from iron and steel production revealed that there are limited commercial options beyond the two standard steel making technologies (blast furnace – basic oxygen furnace and electric arc furnace with or without direct reduction) there are limited commercially proven technologies. Furthermore, of the potential new technologies still in pilot stage, the one with the most GHG reduction potential (molten oxide electrolysis with decarbonized electricity) requires 20 to 30 times more electricity than the best in class electric arc furnaces. An interesting observation related to iron and steel was the importance of introducing new product design guidelines to make separation of steel easier to increase the volume of scrap and reduce its cost.

The potential options identified for reducing GHG emissions from mining, were to either electrify operations or replace the fossil fuel input with carbon-free renewable or synthetic liquid and gaseous fuels. In the case of metal processing, the potential options included a combination of using carbon free power for crushing and replacing heat based melting with chemical leaching.

A variety of technical potential options were identified for the refinery and chemical sectors that included the use of lower temperature fermentation and enzymatic processes instead of high temperature and pressure catalytic reactions, and production of hydrogen and synthetic hydrocarbons.

Multiple technical potential options were identified for reducing GHG emissions from the and pulp and paper sectors including novel sludge drying processes, increased use of recycled fibre, anaerobic treatment of effluent to produce combustible bio-gasses and using lignin from biomass to produce aromatics to becoming a supplier of wood pellets for other sectors.

In summary, none of the generic options offer a "silver bullet" for reducing emissions from heavy industry in the short term since each has its own set of challenges. The sheer volume of fossil fuels that needs to be replaced is prohibitively large to be replaced by carbon free synthetic or renewable alternates in the near future. Most industrial facilities may not have the scale or location to make carbon, capture, use and storage viable. Process redesign remains 'a work in progress' for most sectors, and will largely apply only to new build. However, over time and with the right set of policies a tailored combination of the potential technical options nuanced to reflect and suit the regional circumstances can become practical and economic.

Discussion and Conclusions

Canada Can Have a Competitive Advantage as a Low Carbon Commodity Producer

Given that there will be a growing demand for conventional and new bulk commodities, production of low carbon commodities will be a competitive advantage for any country in a low carbon world.

Canada is well positioned to be a low carbon commodity producer in the future, because of our vast natural resource endowment, our trained work force and research capability and because of the industry expertise and the capital we have invested in our resource and heavy industry sector. Access to decarbonized electricity is another important advantage for Canada. We already have very clean electricity compared to the rest of the world, and we have significant potential for additional hydroelectricity and wind and solar renewables.

All of the above would suggest that Canada's path to decarbonisation should not be through de-industrialization.

Supportive Policies Required

Canada has a potentially bright future in decarbonized heavy industry. A clear policy framework needs to be put in place today, to turn this potential into competitive economic advantage in the low carbon world of the future.

- Federal and provincial governments need to send clear signal that Canada's path to decarbonisation is not through de-industrialization
- Canada and its regions need a heavy industry decarbonisation plan that builds on our competitive advantages (electrification, primary extraction and processing, reorganization of steel recycling, biomass for bio-chemical products and fuels)
- Clear carbon policy needs to be coupled with protection against unfair exogenous competition for the trade exposed commodity producers
- Consideration needs to be given to the high capital base and long-term investment cycles for sectors like mining, chemicals, steel, pulp and paper, in mapping out a viable path to decarbonizing these sectors.
- Careful planning is needed to ensure adequate combination of energy supply and infrastructure is in place to support decarbonisation of heavy industry

Industry is Ready and a Willing Partner

IGUA hopes that this study will start a dialogue among the stakeholders needed to transition Canada's heavy industry to a low carbon future. There is no question that the world will continue to need material goods. Canada has several competitive advantages owing to our natural resource bounty, ingenuity in bringing industrial goods to market and a geography that allows for a multitude of low-carbon technologies to be deployed and tested. The transition of Canada's heavy industry to a low carbon future will not happen over night. But with collaboration between governments, industry and research institutions there exists the long-term potential to remake Canada's industrial landscape and reap the economic benefits of the demand for low-carbon goods in a carbon conscious world.